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TOWNSEND and TOWNSEND and CREW LLP

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PATENT
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

HICHEM M'SAAD et al.

Application No.: 10/020,461

Filed: December 14, 2001

For: METHOD OF MANUFACTURING AN OPTICAL CORE

Confirmation No. 9343

Examiner: Hoffmann, John M.

Technology Center/Art Unit: 1731

APPELLANTS' BRIEF UNDER 37 CFR §41.37

Mail Stop **Appeal Brief**
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Further to the Notice of Appeal mailed on April 14, 2006 for the above-referenced application, Appellants submit this Brief on Appeal.

1. REAL PARTY IN INTEREST

The real party in interest is Applied Materials, Inc.

2. RELATED APPEALS AND INTERFERENCES

This application is related to U.S. Pat. Appl. No. 10/997,715 ("the '715 application") for which a Notice of Appeal was filed on February 28, 2006. The current appeal may be related to the appeal in the '715 application, and Board decisions in either appeal may affect or have a bearing on Board decisions in the other appeal. An Appeal Brief was filed in the '715 application on April 25, 2006.

No other prior or pending appeals, interferences, or judicial proceedings are known that are related to, will directly affect, will be directly affected by, or have a bearing on the Board decision in this appeal.

3. STATUS OF CLAIMS

Claims 1-4, 6-13, 15-18 and 21-42 are pending in the application, of which claims 17 and 18 are withdrawn from consideration pending allowance of a generic claim. Claims 1-4, 6-13, 15-16 and 21-42 stand rejected pursuant to a Final Office Action mailed January 17, 2006 ("the Final Office Action").

The rejections of each of Claims 1-4, 6-13, 15-16 and 21-42 are believed to be improper and are the subject of this Appeal.

4. STATUS OF AMENDMENTS

No amendments have been filed subsequent to the mailing of the Final Office Action on January 17, 2006.

5. SUMMARY OF CLAIMED SUBJECT MATTER

The claimed invention relates to the formation of an optical waveguide with high-density plasma deposition ("HDP") processing techniques (Application, p. 3, ll. 22-23). As defined in the specification, a high-density plasma is defined to have an ion density that is equal

to or exceeds 10^{11} ions/cm^3. (*id.*, p. 5, ll. 28-29). A wide application of HDP processes has previously been used in semiconductor processing to provide methods for fabricating electronic integrated circuits. In contrast, embodiments of the invention are instead concerned with the use of HDP processes for the fabrication of optical structures (*id.*, p. 5, l. 30 - p. 6, l. 2). These fields are distinct for multiple reasons. First, the scale of the applications is very different, with electronic applications having structures on the scale of about 0.2 – 1.0 μm, and optical applications having structures on the scale of 10 – 20 μm, *i.e.* about an order of magnitude or two larger. This difference is especially relevant to gapfill problems because the mechanism by which gapfill is achieved results from a complex interplay of process parameters, ionic-species density, ion kinetic energy, and the like, that affect differently-sized structures differently.

Moreover, the relevant physical properties in electronic and optical applications are different because the structures are used for different purposes. Electronic applications are concerned with providing structures having desirable electrical performance, which is generally characterized by the dielectric constant of the material; optical applications are instead concerned with providing structures having desirable optical performance, which is generally characterized by the refractive index of the material with, e.g., extremely tight film homogeneity across the substrate and between wafer to wafer (*see generally id.*, p. 6, ll. 1 - 10). The relevance of refractive index is especially pronounced in the fabrication of optical waveguides because the ability to transmit light by total internal reflection within the structures is highly dependent on the specific refractive indices of different parts that make up the waveguide (*id.*, p. 1, l. 30 – p. 2, l. 1).

The claims presently under consideration relate to methods, systems, and media for forming optical waveguides including the formation of a high-density plasma and the deposition of a plurality of separated silicate glass optical cores on an undercladding layer using the high-density plasma, wherein the optical cores define a sequence of gaps. Each of the silicate glass optical cores is formed with a refractive index greater than a refractive index of the undercladding layer such that each of the optical cores has a contrast relative to the undercladding layer greater than 2%. These high contrast cores are advantageous because as the contrast increases, the refractive index of the core is typically increased, and thus more of the

light is optically confined in the core, thereby allowing for thinner optical cores. Figure 4 of the application illustrates this concept. (*id.*, p. 8, ll. 27-30.)

A. Independent Claim 1

Independent Claim 1 sets forth steps for a process claimed by the inventor for forming an optical waveguide. A silicon source gas is flowed into a process chamber, an oxygen source gas is flowed into the process chamber, and high-density plasma is formed in the process chamber from the silicon source gas and the oxygen source gas. A plurality of separated silicate glass optical cores (*e.g.*, *id.*, Fig. 5, reference 510A, 510B) are formed over an undercladding layer (*e.g.*, *id.*, Fig. 5, reference 502) disposed within the process chamber with the high-density plasma. In accordance with claim 1, the plurality of separated silicate glass optical cores define a sequence of gaps (*e.g.*, *id.*, p. 11, l. 13 - p. 13, l. 7). An uppercladding layer (*e.g.*, *id.*, Fig. 5, reference 503) is then deposited over the plurality of separated silicate glass optical cores. Again, in accordance with the claims, each of the silicate glass optical cores is formed with a refractive index greater than the refractive index of the undercladding layer such that each of the optical cores has a contrast relative to the undercladding layer greater than 2%.

B. Independent Claim 15

Independent Claim 15 sets forth a method similar to that of claim 1, further specifying that the formation of the plurality of optical cores comprises depositing a substantially continuous optical core layer on the undercladding layer with the high-density plasma. The sequence of gaps is then etched in the optical core layer to form the separated optical cores. Claim 15 further recites that the depositing of the uppercladding layer comprises depositing the uppercladding layer within the gaps.

C. Independent Claim 29

Independent Claim 29 sets forth basic elements of a substrate processing system claimed by the inventor for forming an optical waveguide. The system comprises a housing defining a process chamber; a high-density plasma generating system; a substrate holder; a gas-delivery system including sources for a silicon-containing gas, an oxygen-containing gas, and a dopant-containing gas; a pressure-control system; a controller for controlling the high-density

plasma generating system, the gas-delivery system, and the pressure-control system; and a memory coupled to the controller. In accordance with claim 29, the memory comprises a computer-readable medium having a computer-readable program embodied therein for directing operation of the system to form an optical waveguide. The computer-readable program includes: instructions to flow a gaseous mixture containing flows of the silicon-containing gas, the oxygen-containing gas, and the dopant-containing gas into the process chamber; instructions to maintain a pressure of less than 100 millitorr within the process chamber; and instructions to form a high-density plasma in the process chamber from the gaseous mixture by providing energy to the process chamber inductively with an RF power density greater than 3 Watts/cm^2. The computer-readable program further includes instructions to form a plurality of separated silicate glass optical cores over an undercladding layer disposed within the process chamber within the high-density plasma, wherein the separated silicate glass optical cores define a sequence of gaps, and the dopant-containing gas causes each of the plurality of optical cores to have a refractive index above 1.46 and greater than a refractive index of the undercladding layer such that each of the optical cores has a contrast relative to the undercladding layer greater than 2%. Finally, as recited in Claim 29, the computer readable program includes instructions to deposit an uppercladding layer over the plurality of separated silicate glass optical cores.

D. Independent Claim 37

Independent Claim 37 is directed to a computer-readable storage medium itself, having a computer-readable program embodied therein for directing operation of a substrate processing system. In accordance with claim 37, the substrate processing system directed by the computer-readable storage medium includes a process chamber; a plasma generation system; a substrate holder; and a gas delivery system configured to introduce gases into the process chamber. The computer-readable program includes instructions for operating the substrate processing system to form an optical waveguide in accordance with the following: flowing a silicon source gas into the process chamber; flowing an oxygen source gas into the process chamber; flowing a dopant source gas into the process chamber; maintaining a pressure of less than 100 millitorr in the process chamber; forming a high-density plasma in the process chamber

from the silicon source gas, the oxygen source gas, and the dopant source gas by providing energy to the process chamber inductively with an RF power density greater than 3 Watts/cm^2; forming a plurality of separated silicate glass optical cores over an undercladding layer disposed within the process chamber with the high-density plasma; and depositing an uppercladding layer over the plurality of separated silicate glass optical cores. Again, in accordance with the claim, the separated silicate glass optical cores define a sequence of gaps; and the dopant containing source causes each of the plurality of optical cores to have a refractive index above 1.46 and greater than a refractive index of the undercladding layer such that each of the optical cores has a contrast relative to the undercladding layer greater than 2%

6. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

1. Whether Claims 1-2, 15-16, and 22-42 are unpatentable under 35 U.S.C. §103(a) over U.S. Pat. No. 6,154,582 ("Bazylenko") in view of U.S. Pat. No. 5,221,309 ("Kyoto"), optionally further in view of U.S. Pat. No. 5,136,671 ("Dragone").

2. Whether Claims 1-4, 6-13, 21-26, and 29-42 are unpatentable under 35 U.S.C. §103(a) over U.S. Pat. No. 6,614,977 to Johnson in view of Kyoto, optionally in view of Dragone.

7. ARGUMENT

For a rejection to be maintained under 35 U.S.C. §103(a), the Examiner must provide a factually supported *prima facie* case of obviousness. Manual of Patent Examining Procedure, Eighth Edition, Third Revision, August 2005, 2131. Such a *prima facie* case requires, *inter alia*, that all elements of the claims be taught or suggested by the cited references, and that there be some motivation to combine or modify the reference teachings as proposed. The rejections are respectfully believed to be deficient in at least both of these respects, that is, the rejections fail to teach or suggest each and every limitation of the claims and, in addition, that there is no adequate motivation provided that would suggest a combination or modification of the reference teachings to arrive at the recited claims.

A. Bazylenko in view of Kyoto, optionally further in view of Dragone

1. Independent Claim 1

In rejecting independent Claim 1, the Final Office Action relies on a combination of teachings from two or three references. Bazylenko is admitted to not disclose the plurality of separated cores, but it is asserted that "it would have been obvious to create more than one waveguide core so as to be able to multiply the amount of data carried." (Final Office Action mailed February 14, 2005, pp. 3-4, cited in subsequent offices actions). Kyoto is referenced as allegedly teaching that a large index difference allows for easy propagation of light, and that a difference of up to 4% is "usual" in certain applications. (Office Action mailed August 18, 2005, p. 4, cited in subsequent office actions). Dragone is then optionally relied on to allegedly show that multiple separated waveguides are conventional. (Final Office Action mailed February 14, 2005, p. 3, cited in subsequent offices actions).

At a minimum, in order to arrive at the presently claimed invention (in independent claim 1), one of skill would have to modify Bazylenko to at least (1) incorporate a plurality of separated silicate glass optical cores over an undercladding layer, (2) wherein the optical cores define a sequence of gaps, (3) such that each of the optical cores has a contrast relative to the undercladding layer greater than 2%.

As acknowledged by the Examiner, whatever else Bazylenko does disclose, it does not disclose a plurality of optical cores. Further, there is no specific disclosure to teach or suggest that the plurality of optical cores should define a sequence of gaps. The various Office Actions to date have been dismissive of this distinction, asserting that "it would have been obvious to create more than one waveguide core so as to be able to multiply the amount of data carried" (id., pp. 3-4). This assertion is purely speculative and lacks any support in Bazylenko. There is no disclosure in Bazylenko to suggest the desirability of more data communication pathways, and it is not at all apparent how the structure would (or could) be arranged to provide such pathways. In particular the (single) optical core in Bazylenko is intended to couple light from an optical arrangement (such as an optical fiber connected to an optical system) into an electro-optical transducer to provide an electrical signal to an external circuit or device (Bazylenko, Col. 4, l. 66 – Col. 5, l. 18). There is nothing in Bazylenko to suggest that

additional pathways between the optical arrangement and the electro-optical transducer are desirable. The disclosure of Bazylenko on its face appears to indicate that the objective of coupling light between the optical arrangement and the electro-optical transducer is fully achieved with the structure of the optical core as described. (See, *e.g.*, Bazylenko, Summary of the Invention) Furthermore, it is not apparent that additional optical cores provided to increase the number of pathways between the optical arrangement and the electro-optical transducer could be arranged geometrically to "defin[e] a sequence of gaps."

The Examiner's reliance on Dragone to illustrate multiple, separate waveguides as conventional does nothing to remedy these deficiencies. Whatever else Dragone does disclose, it does not disclose single waveguides with multiple cores defining a sequence of gaps. Rather, it discloses a multiplex system of a plurality of separate waveguides. The Examiner points to no specific disclosure concerning the optical cores within the single waveguides of Dragone. Further, the Examiner provides no direction as to how one of skill would be led to modify the production methodologies of Bazylenko related to making waveguides based on the disclosure of Dragone related to multiplexes of waveguides. More particularly, Dragone is <u>not</u> directed to the type of layered structures that result from implementation of the claimed methods. It instead describes a multiplexing apparatus that uses star couplers, and does not teach or suggest "forming a plurality of separated optical cores over [an] undercladding layer, the plurality of optical cores defining a sequence of gaps." The fact that Dragone teaches that multiple waveguides may form part of an integrated optical interconnection structure is irrelevant to the claimed <u>fabrication method</u>. In Fig. 1 of Dragone, waveguides and arrays 16 and 20 remain separated by distances *t* and *t'* at the star-coupler boundaries (Dragone, Col. 2, ll. 50 – 60). Even if one of skill in the art were to look to combine the teachings of Dragone and Bazylenko, at best they would be lead to separately manufacture individual optical cores and later combine the cores into a multiplex *via* a connector, as taught by Dragone.

For completeness, the Examiner's additional remarks regarding the duplication of parts are noted. Appellant is not claiming mere duplication of a prior art structure and therefore asserting that such a duplicated structure is patentable. Instead, Appellant is claiming a method for forming an optical waveguide that includes a number of steps in combination. The mere fact

that one of those steps in isolation recites the formation of a plurality of structures does not render the claim unpatentable — the way in which that step combines with the other recited steps is what is relevant in assessing patentability.

Nonetheless, even assuming *arguendo* that one of skill in the art would be motivated to attempt to incorporate additional cores into the waveguide disclosed by Bazylenko, there is no teaching or suggestion of adequate methodologies to obtain a plurality of optical cores such that each of the optical cores has a contrast relative to the undercladding layer greater than 2%. Although Bazylenko does disclose that possible index differences between the core and the cladding layers may range from "0.004 to about 0.02," the only embodied difference is about 0.008. (Bazylenko, Col. 6, ll. 25-33 and Example 1). As such, Bazylenko does not teach, suggest, or contemplate, a plurality of optical cores with index contrasts as claimed.

With regard to the alleged teachings of Kyoto, Kyoto merely mentions in passing that "large aperture optical fibers" may have contrasts of about 2 to 4%, without any indication, explanation, or discussion of particular methods by which one may be able to achieve such contrast levels, or the applicability of such teachings to other types of fibers such as waveguides with multiple cores. Moreover, the methodologies which are the focus of Kyoto are flame hydrolysis methodologies, which are not directly applicable to the PECVD methodologies exemplified in Bazylenko, much less to the claimed high-density multi-core waveguide preparation methodologies. As such, one of skill in the art would not look to combine the teachings of Kyoto and Bazylenko with any reasonable expectation of success.[1]

Since the cited art does not disclose all of the recited elements of independent Claim 1 and because the Final Office Action has failed to establish a motivation to combine the

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[1] The Examiner asserts in the Final Office Action mailed January 17, 2006, that Kyoto is cited as evidence that "it is not invention to provide an index greater than 2%," and that Official Notice could have just as easily been taken "of the well-known fact that the larger the difference, the better the waveguideing." (Final Office Action mailed January 17, 2006, p. 3). In support of such allegations, the Examiner makes the statement that "it is only the difference that is important, not the mode of creating the difference." (*id.*) Again, the claims are directed to methods for creating optical waveguides with a plurality of optical cores with specific refractive indices. Thus, the modes of creating the differences are in fact relevant to the claims. One of skill must be motivated to modify the mode [not quite sure what you mean by "modify the mode" Perhaps expand on what this means, unless it is clear to you] of obtaining the differences as disclosed in the cited references in a specific manner so as to arrive at the specific methodologies claimed. The motivation to modify the reference in the manner specifically required by the claims must be found in the prior art, and not be based on applicants' disclosure. *See M.P.E.P.* §§2143.01 and 2143.03.

cited art, no *prima facie* case under §103 has been established. The claims are accordingly believed to be patentable. It is additionally noted that the rejections rely on isolated teachings of a number of references, without specific reference to how one of skill would modify the teachings of Bazylenko in practice so as to arrive at the present invention. The manner in which the disclosures have been selectively drawn from the references suggests that the present claims have improperly been used as a roadmap to define the invention:

> It is impermissible to use the claimed invention as an instruction manual or "template" to piece together the teachings of the prior art so that the claimed invention is rendered obvious. This court has previously stated that '[o]ne cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention."
> *In re Fritch*, 972 F.2d 1260, 1265, 23 U.S.P.Q.2d 1780, 1784 (Fed. Cir. 1992), *quoting In re Fine*, 837 F.2d 1071, 1074, 5 U.S.P.Q.2d 1596, 1600 (Fed. Cir. 1988).

2. Independent Claim 15

Independent Claim 15 is patentable for at least each of the reasons discussed above with regard to Claim 1. In addition, Claim 15 specifically provides that a substantially continuous optical core layer is deposited on the undercladding layer with the high-density plasma, and the sequence of gaps are etched within the optical core layer to form the separated optical cores. The uppercladding layer is then deposited within the gaps.

As discussed above, Bazylenko does not disclose multiple cores. Further, it is submitted that there is no suggestion in Bazylenko to specifically modify the fabrication methods of Bazylenko so as to arrive at a method wherein a substantially continuous optical core layer is deposited on an undercladding layer, and wherein a sequence of gaps are etched within the optical core layer so as to form a plurality of separated optical cores with specific refractive index properties. Indeed, there is no teaching or suggestion to indicate the desirability of having multiple cores <u>within</u> the same waveguide structure to steer light to a single electro-optic transducer, much less multiple cores having the specified refractive index contrast relative to the undercladding layer.

Again, Dragone does nothing to provide one of skill in the art with motivation to modify the teachings of Bazylenko in these regards. Dragone is <u>not</u> directed to the type of layered structures that result from implementation of the claimed methods. It instead describes a multiplexing apparatus that uses star couplers, and does not teach or suggest "forming a plurality

of separated optical cores over [an] undercladding layer, the plurality of optical cores defining a sequence of gaps." The fact that Dragone teaches that multiple waveguides may form part of an integrated optical interconnection structure is irrelevant to the claimed <u>fabrication method</u>. In Fig. 1 of Dragone, waveguides and arrays 16 and 20 remain separated by distances *t* and *t*' at the star-coupler boundaries (Dragone, Col. 2, ll. 50 – 60). Even if one of skill in the art were to look to combine the teachings of Dragone and Bazylenko, at most they would be lead to separately manufacture individual optical cores and later combine the cores into a multiplex *via* a connector, as taught by Dragone.

Further, as discussed above, Kyoto merely mentions in passing that "large aperture optical fibers" may have contrasts of about 2 to 4%, without any indication , explanation, or discussion of particular methods by which one may be able to achieve such contrast levels, or the applicability of such teachings to other types of fibers such as waveguides with thinner cores. Moreover, the methodologies which are the focus of Kyoto are flame hydrolysis methodologies, which are not directly applicable to the PECVD methodologies exemplified in Bazylenko, much less to the claimed high-density multi-core waveguide preparation methodologies. As such, one of skill in the art would not look to combine the teachings of Kyoto and Bazylenko with any reasonable expectation of success.

3. Independent Claims 29 and 37

Independent Claims 29 and 37 are believed to be patentable for at least the reasons discussed above with regard to Claim 1.

4. Dependent Claims

Each of the dependent claims is believed to be patentable by virtue of its dependence from a patentable independent claim. The following additional remarks are made regarding certain specific dependent claims.

With regard to claims 24-25 (and dependent claim 26), and claims 27, 31-33, and 39-41, as well as non-rejected claims 3-11, relating to nitrogen source gases, Bazylenko specifically teaches that the disclosed methods have the advantage of being carried out in the absence of nitrogen. The use of an oxidant that does not contain nitrogen is a specifically stated purpose of Bazylenko. Thus, Bazylenko teaches away from the use of nitrogen source gases in

the disclosed methods, and thus one of skill in the art would not be lead to modify the teachings of Bazylenko in this regard. Moreover, even assuming *arguendo* that one of skill in the art would view the absence of nitrogen source gases as a "preferred" embodiment, the alleged disclosure of Bazylenko in this regard relates to the use of a hypothetical, disfavored nitrogen-containing oxidant source gas. The claims at issue recite the use of an oxygen source gas as well as a nitrogen dopant source gas. Bazylenko clearly fails to contemplate or suggest the use of a nitrogen dopant in addition to an oxygen source. Further, certain of the dependent claims expressly recite that the nitrogen source gas is molecular nitrogen. As described in the specification, PECVD methods generally do not produce enough energy to break the nitrogen-nitrogen bond of molecular nitrogen. One of skill in the art would still not be lead to include a disfavored nitrogen oxidant source gas in addition to an additional nitrogen dopant source gas, such as molecular nitrogen in the methods of Bazylenko. Moreover, there is no suggestion or motivation to arrive at the specifically claimed flow rates or source gas ratios, as recited in certain of the dependent claims.

B. <u>Johnson in view of Kyoto, optionally further in view of Dragone</u>

1. Independent Claims

As above, in rejecting the independent claims, the Final Office Action relies on a combination of teachings from two or three references. Johnson is admitted to not disclose the plurality of separated cores, but it is again asserted that "it would have been obvious to create more than one waveguide core so as to be able to multiply the amount of data carried." (Final Office Action mailed February 14, 2005, p. 4, cited in subsequent Offices Actions). Kyoto is referenced as allegedly teaching that a large index difference allows for easy propagation of light, and that a difference of up to 4% is "usual" in certain applications. (Office Action mailed August 18, 2005, p. 5, cited in subsequent Office Actions). Dragone is then optionally relied upon to allegedly show that multiple separated waveguides are conventional. (Final Office Action mailed February 14, 2005, p. 4).

Similar to the discussion above, in order to arrive at the presently claimed invention, one of skill would have to modify Johnson to at least (1) incorporate a plurality of

separated silicate glass optical cores over an undercladding layer, (2) wherein the optical cores define a sequence of gaps, (3) such that each of the optical cores has a contrast relative to the undercladding layer greater than 2%.

In this regard, and as acknowledged by the Examiner, whatever else Johnson does disclose, it does not disclose a plurality of optical cores. Further, there is no specific disclosure to teach or suggest that the plurality of optical cores should define a sequence of gaps. The Examiner's reliance on Dragone to illustrate multiple, separate waveguides as conventional does nothing to remedy these deficiencies. Again, Dragone does not disclose single waveguides with multiple cores defining a sequence of gaps. Rather, it discloses a multiplex system of a plurality of <u>separate</u> waveguides. The Examiner points to no specific disclosure concerning a plurality of optical cores <u>within</u> a single waveguide. Further, the Examiner provides no direction as to how one of skill in the art would be lead to modify the fabrication methodologies of Johnson related to making waveguides based on the disclosure of Dragone related to multiplexes of waveguides. Even if one of skill in the art were to look to combine the teachings of Dragone and Johnson, at most they would be lead to separately manufacture individual optical cores, as in Johnson, and later combine the cores into a multiplex *via* a connector, as taught by Dragone.

Nonetheless, even assuming *arguendo* that one of skill in the art would be motivated to attempt to incorporate additional cores into the waveguide disclosed by Johnson, there is no teaching or suggestion of adequate methodologies, systems or media to obtain a plurality of optical cores such that each of the optical cores has a contrast relative to the undercladding layer greater than 2%. Although Johnson does disclose that the optical cladding can include any number of materials having a lower index of refraction than the thin film forming the optical component, Johnson is silent with regard to the actual magnitude of difference in refractive index, or the desirability of maintaining a specific level of contrast. (See, e.g., Johnson, Col. 6-7). In terms of propagation loss, Johnson is focused on hydrogen content alone. As such, Johnson does not teach, suggest, or contemplate, a plurality of optical cores with index contrasts as now claimed.

With regard to the alleged teachings of Kyoto, Kyoto merely mentions in passing that "large aperture optical fibers" may have contrasts about 2 to 4%, without any indication,

explanation, or discussion of particular methods by which one may be able to achieve such contrast levels, or the applicability of such teachings to other types of fibers such as waveguides with thinner cores. As explained in the present specification, in certain embodiments, a benefit of the present invention is that multi-core waveguides may be produced with thinner cores, due to the increased contrast ratios (*e.g.*, specification p. 8, l. 20 - p. 9, l. 13). In Kyoto, there is no indication that such contrast levels are desirable or obtainable in smaller aperture fibers, much less in multi-core configurations. Moreover, the methodologies which are the focus of Kyoto are flame hydrolysis methodologies, which are not directly applicable to the PECVD methodologies exemplified in Johnson, much less to the claimed high-density multi-core waveguide preparation methodologies. As such, one of skill in the art would not look to combine the teachings of Kyoto and Johnson with any reasonable expectation of success.

Since the cited art does not disclose all of the recited elements of the independent claims, and because the Final Office Action has failed to establish a motivation to combine the cited art, no *prima facie* case under §103 has been established. The claims are accordingly believed to be patentable. Further, it is noted that the rejections rely on an isolated teaching of a number of references, without specific reference to how one of skill in the art would modify the teachings of Bazylenko in practice so as to arrive at the present invention. The manner in which disclosures have been selectively drawn from the references suggests that the present claims have improperly been used as a roadmap to define the invention.

2. Dependent Claims

Each of the dependent claims is believed to be patentable by virtue of its dependence from a patentable independent claim. The following additional remarks are made regarding certain specific dependent claims.

Further, with regard to claim 2 (and dependent claims 3-11), claim 12, claim 22 (and dependent claims 23-28), claim 29 (and dependent claims 30-36), and claim 37 (and dependent claims 38-42), the deposition conditions taught by Johnson do not amount to or suggest the recited conditions for forming the high-density plasma as required by the claims. More particularly, the recited pressure, temperature and RF power density differ from the conditions disclosed by Johnson, and given the limitations of exemplified PECVD

methodologies in this regard, one of skill in the art would not be lead to optimize the temperature, pressure and/or power density in the ranges claimed based on the teachings of Johnson. For instance, the only specific deposition conditions described by Johnson involve a PECVD system, wherein a chamber pressure of about 300 millitorr and temperature of 300 °C are utilized. (Johnson, Col. 7, ll. 13-22). Absence a motivation to modify the teachings of Johnson to specifically move to higher-density plasma methodologies, one of skill in the art would not be lead to arrive at the claimed deposition conditions.

With regard to claims 4, 25-27, 32-33, and 40-41, as well as non-rejected claims 7-11, relating to molecular nitrogen source gases, Johnson does not disclose the use of molecular nitrogen as a source gas which is incorporated into the plasma. As described in the specification, PECVD methods do not generally produce enough energy to break the nitrogen-nitrogen bond of molecular nitrogen. As such, one of skill in the art would not be lead to select molecular nitrogen as a possible nitrogen source gas based on the teachings of Johnson. Moreover, there is no suggestion or motivation to arrive at the specifically claimed flow rates or source gas ratios, as recited in certain of the dependent claims.

For at least these reasons, all claims are believed to be patentable over the art of record, and withdrawal of the rejections is respectfully requested.

8. CONCLUSION

Appellant believes that the above discussion is fully responsive to all grounds of rejection set forth in the application. Please deduct the requisite fee of $500.00 pursuant to 37 C.F.R. §1.17(c) from Deposit Account 20-1430 and any additional fees that may be due in association with the filing of this Brief.

Respectfully submitted,

Dated: July 14, 2006

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9. CLAIMS APPENDIX

The claims involved in this Appeal are as follows:

1. (Previously Presented) A method of forming an optical waveguide, the method comprising:

flowing a silicon source gas into a process chamber;

flowing an oxygen source gas into the process chamber;

forming a high-density plasma in the process chamber from the silicon source gas and the oxygen source gas;

forming a plurality of separated silicate glass optical cores over an undercladding layer disposed within the process chamber with the high-density plasma, the separated silicate glass optical cores defining a sequence of gaps; and

depositing an uppercladding layer over the plurality of separated silicate glass optical cores,

wherein each of the silicate glass optical cores is formed with a refractive index greater than a refractive index of the undercladding layer such that each of the optical cores has a contrast relative to the undercladding layer greater than 2%.

2. (Previously Presented) The method of claim 1 further comprising maintaining a pressure within the process chamber less than 100 millitorr while forming the silicate glass optical cores, wherein forming the high-density plasma comprises providing energy to the process chamber inductively with an RF power density greater than 3 Watts/cm^2.

3. (Previously Presented) The method of claim 2 further comprising flowing a nitrogen source gas into the process chamber, wherein forming the high-density plasma comprises forming the high-density plasma from the silicon source gas, the oxygen source gas, and the nitrogen sources gas, whereby the plurality of optical cores comprise~~s~~ silicon, oxygen, and nitrogen.

4. (Original) The method of claim 3 wherein the nitrogen source gas is molecular nitrogen.

5. (Canceled).

6. (Previously Presented) The method of claim 3 wherein the oxygen source gas and silicon source gas are flowed to provide a ratio of oxygen atoms to silicon atoms in the high-density plasma greater than 3:1.

7. (Previously Presented) The method of claim 3 wherein the silicon source gas comprises silane, the oxygen source gas comprises molecular oxygen, and the nitrogen source gas comprises molecular nitrogen.

8. (Previously Presented) The method of claim 7 wherein the molecular oxygen is flowed into the process chamber at a rate greater than 1.5 times a rate at which the silane is flowed into the process chamber.

9. (Previously Presented) The method of claim 7 wherein the molecular oxygen is flowed into the process chamber at a rate between 200 and 600 sccm.

10. (Previously Presented) The method of claim 7 wherein the molecular nitrogen is flowed into the process chamber at a rate between 0.5 and 5.0 times a rate at which the silane is flowed into the process chamber.

11. (Previously Presented) The method of claim 7 wherein the molecular nitrogen is flowed into the process chamber at a rate between 300 and 500 sccm.

12. (Previously Presented) The method of claim 1 further comprising maintaining a temperature within the process chamber while forming the silicate glass optical cores greater than 600°C.

13. (Previously Presented) The method of claim 1 wherein each of the silicate glass optical cores comprises a phosphorus doped silicate glass optical core or germanium doped silicate glass optical core.

14. (Canceled)

15. (Previously Presented) A method of forming an optical waveguide, the method comprising:

flowing a silicon source gas into a process chamber;

flowing an oxygen source gas into the process chamber;

forming a high-density plasma in the process chamber from the silicon source gas and the oxygen source gas;

forming a plurality of separated silicate glass optical cores over an undercladding layer disposed within the process chamber with the high-density plasma, the separated silicate glass optical cores defining a sequence of gaps; and

depositing an uppercladding layer over the plurality of separated silicate glass optical cores,

wherein each of the silicate glass optical cores is formed with a refractive index greater than a refractive index of the undercladding layer such that each of the optical cores has a contrast relative to the undercladding layer greater than 2%;

wherein forming the plurality of optical cores comprises:

depositing a substantially continuous optical core layer on the undercladding layer with the high-density plasma; and

etching the sequence of gaps within the optical core layer to form the separated optical cores, and

wherein depositing the uppercladding layer comprises depositing the uppercladding layer within the gaps.

16. (Previously Presented) The method of claim 15 wherein forming the plurality of separated optical cores is performed without applying an RF bias to the undercladding layer.

17. (Withdrawn) The method of claim 1 wherein forming the plurality of optical cores comprises:

etching a plurality of trenches in the undercladding layer; and

depositing silicate glass within each of the trenches with the high-density plasma.

18. (Withdrawn) The method of claim 17 wherein depositing silicate glass within each of the trenches comprises applying an RF bias to the undercladding layer.

19. – 20. (Canceled).

21. (Previously Presented) The method of claim 1 further comprising annealing the plurality of optical cores.

22. (Previously Presented) The method of claim 1, further comprising:

flowing a dopant source gas into the process chamber; and

maintaining a pressure of less than 100 millitorr in the process chamber, wherein:

forming the high-density plasma comprises providing energy to the process chamber inductively with an RF power density greater than 3 Watts/cm^2 and forming the high-density plasma from the silicon gas source, the oxygen gas source, and the dopant gas source; and

the dopant source gas causes each of the plurality of optical cores to have a refractive index above 1.46.

23. (Previously Presented) The method of claim 22 wherein the oxygen source gas and silicon source gas are flowed to provide a ratio of oxygen atoms to silicon atoms is in the high-density plasma greater than 3:1.

24. (Previously Presented) The method of claim 22 wherein the dopant source gas is a nitrogen source gas, whereby the optical core comprises silicon, oxygen, and nitrogen.

25. (Original) The method of claim 24 wherein said nitrogen source gas is molecular nitrogen.

26. (Original) The method of claim 25 wherein the silicon source gas is silane.

27. (Previously Presented) The method of claim 26 wherein the molecular nitrogen is flowed into the process chamber at a rate between 0.5 and 5.0 times a rate at which the silane is flowed into the process chamber.

28. (Original) The method of claim 22 wherein the dopant source gas is a phosphorus containing gas or germanium containing gas.

29. (Previously Presented) A substrate processing system comprising:

a housing defining a process chamber;

a high-density plasma generating system operatively coupled to the process chamber;

a substrate holder configured to hold a substrate during substrate processing;

a gas-delivery system configured to introduce gases into the process chamber, including sources for a silicon-containing gas, an oxygen-containing gas, and a dopant-containing gas;

a pressure-control system for maintaining a selected pressure within the process chamber;

a controller for controlling the high-density plasma generating system, the gas-delivery system, and the pressure-control system; and

a memory coupled to the controller, the memory comprising a computer-readable medium having a computer-readable program embodied therein for directing operation of the substrate processing system to form an optical waveguide, the computer-readable program including:

instructions to flow a gaseous mixture containing flows of the silicon-containing gas, the oxygen-containing gas, and the dopant-containing gas into the process chamber;

instructions to maintain a pressure of less than 100 millitorr within the process chamber; and

instructions to form a high-density plasma in the process chamber from the gaseous mixture by providing energy to the process chamber inductively with an RF power density greater than 3 Watts/ cm^2;

instructions to form a plurality of separated silicate glass optical cores over an undercladding layer disposed within the process chamber with the high-density plasma, wherein:

the separated silicate glass optical cores define a sequence of gaps; and

the dopant-containing gas causes each of the plurality of optical cores to have a refractive index above 1.46 and greater than a refractive index of the undercladding layer such that each of the optical cores has a contrast relative to the undercladding layer greater than 2%; and

instructions to deposit an uppercladding layer over the plurality of separated silicate glass optical cores.

30. (Previously Presented) The substrate processing system of claim 29 wherein the instructions to flow the gaseous mixture include instructions to flow the oxygen-containing gas and the silicon-containing gas to provide a ratio of oxygen atoms to silicon atoms in the high-density plasma greater than 3:1.

31. (Previously Presented) The substrate processing system of claim 29 wherein the dopant-containing gas comprises a nitrogen-containing gas, whereby each of the plurality of optical cores comprises silicon, oxygen, and nitrogen.

32. (Original) The substrate processing system of claim 31 wherein the silicon-containing comprises silane and the nitrogen-containing gas includes molecular nitrogen.

33. (Previously Presented) The substrate processing system of claim 32 wherein the instructions to flow the gaseous mixture include instructions to flow the molecular nitrogen

into the process chamber at a rate between 0.5 and 5.0 times a rate at which the silane is flowed into the process chamber.

34. (Previously Presented) The substrate processing system of claim 29 wherein the substrate holder comprises an electrostatic chuck, and wherein computer-readable program further includes instructions for turning the electrostatic chuck off during deposition of the plurality of silicate glass optical cores.

35. (Previously Presented) The substrate processing system of claim 29 further comprising a top RF source and a side RF source, wherein the instructions to form the high-density plasma include instructions to provide energy to the process chamber inductively with the top and side RF sources, with a ratio of power provided by the top RF source to power provided by the side RF source being between 0.21 and 0.73.

36. (Original) The substrate processing system of claim 29 wherein the dopant containing gas is a phosphorus containing gas or germanium containing gas.

37. (Previously Presented) A computer-readable storage medium having a computer-readable program embodied therein for directing operation of a substrate processing system including a process chamber; a plasma generation system; a substrate holder; and a gas delivery system configured to introduce gases into the process chamber, the computer-readable program including instructions for operating the substrate processing system to form an optical waveguide in accordance with the following:

flowing a silicon source gas into the process chamber;

flowing an oxygen source gas into the process chamber;

flowing a dopant source gas into the process chamber;

maintaining a pressure of less than 100 millitorr in the process chamber;

forming a high-density plasma in the process chamber from the silicon source gas, the oxygen source gas, and the dopant source gas by providing energy to the process chamber inductively with an RF power density greater than 3 Watts/cm^2;

forming a plurality of separated silicate glass optical cores over an undercladding layer disposed within the process chamber with the high-density plasma, wherein:

the separated silicate glass optical cores define a sequence of gaps; and

the dopant containing source causes each of the plurality of optical cores to have a refractive index above 1.46 and greater than a refractive index of the undercladding layer such that each of the optical cores has a contrast relative to the undercladding layer greater than 2%; and

depositing an uppercladding layer over the plurality of separated silicate glass optical cores.

38. (Previously Presented) The computer-readable storage medium of claim 37 wherein the oxygen source gas and silicon source gas are flowed to provide a ratio of oxygen atoms to silicon atoms in the high-density plasma greater than 3:1.

39. (Previously Presented) The computer-readable storage medium of claim 37 wherein the dopant source gas is a nitrogen source gas, whereby each of the plurality of optical cores comprises silicon, oxygen, and nitrogen.

40. (Original) The computer-readable storage medium of claim 39 wherein said nitrogen source gas is molecular nitrogen and the silicon source is silane.

41. (Previously Presented) The computer-readable storage medium of claim 40 wherein the molecular nitrogen is flowed into the process chamber at a rate between 0.5 and 5.0 times a rate at which the silane is flowed into the process chamber.

42. (Original) The computer-readable storage medium of claim 37 wherein the dopant source gas is a phosphorus containing gas or germanium containing gas.

10. EVIDENCE APPENDIX

None

11. RELATED PROCEEDINGS APPENDIX

None